International Journal of Textile and
Fashion Technology (IJTFT)
ISSN (P): 2250-2378; ISSN (E): 2319-4510
Vol. 9, Issue 1, Feb 2019, 1-8

EFFECT OF REACTIVE AND VAT DYES ON THE DYEABILITY OF GRAY COTTON KHADI FABRIC USING UNDER TENSION MERCERIZATION TREATMENT

ADYA TIWARI[1], RAJEEV KUMAR[2] & ANJALI[3]

[1]*Assistant Professor, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, India*

[2]*Lecturer, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, India*

[3]*Assistant Professor, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, India*

ABSTRACT

The present study was aimed to assess the effect dyeability of gray cotton khadi fabric based on mercerization treatment. This treatment originated by two methods i.e. slack mercerization and mercerization under tension. The fabric samples were treated at the set temperature i.e. 40°C with varying concentrations i.e. 5%, 15% and 25% for different time periods such as 10 min, 20min, and 30min. The pretreated mercerized cotton khadi fabric samples were dyed with 3% concentration of dye using reactive dye and Vat dye. Dyeing was performed in case of all samples i.e. control, slack mercerized and under tension mercerized fabric samples. Different parameters of mercerization treatment such as the concentration of sodium hydroxide palates and time duration of the treatment were taken on the bases of past studies. The percent dye exhaustion of dyed samples was evaluated by comparing slack mercerized and under tension mercerized khadi samples using single beam UV-Vis Spectrophotometer. Both dyes gave the best results with under tension mercerization as compared to the slack mercerization at all the level of treatment in increasing order. Vat dye gave very good results at 3% concentration of dye and 25% concentration of alkali for 30min using under tension mercerization treatment.

Keywords: Cotton Khadi Fabric, Mercerization under Tension, Percent Dye Exhaustion & Slack Mercerization

Received: Nov 27, 2018; **Accepted:** Dec 17, 2018; **Published:** Jan 04, 2019; **Paper Id.:** IJTFTFEB20191

Original Article

INTRODUCTION

Cotton, the King of fiber kingdom, is the pride of our nation and gift to the world. Cotton termed as "white gold" was used in India as far as 4000 B.C cotton is most versatile and the most widely used textile fiber processing more ideal properties than any other fiber. This is widely available natural fiber used for clothing. Properties of cotton can be further enhanced by finishing treatment[8]. There are many types of finishing treatment which can be applied to cotton fabric such as designing, bleaching, and mercerization etc. Mercerization is one of the most important finishing processes of value addition to cotton material. This method is discovered in 1844 and patented in 1850 by the English calico printer John Mercer and hence fourth this process has been called mercerization [3,7,10].

Mercerization in textiles, a chemical treatment applied to cotton fibers or fabrics to permanently impart a greater affinity for dyes and various chemical finishes. It is also used in the finishing of linen. The fabric is usually singed before mercerization, but mercerization can either precede or follow bleaching. When cotton fibers are immersed in the alkali solution (sodium hydroxide or liquid ammonia) at a specified concentration for a specified time, and then rinsed with stretching[2, 6]. Mercerization causes the flat twisted, ribbon-like cotton fiber to swell into

a round shape and contact in the length. The fiber becomes much lustrous than the original fiber, and its strength is increased by as much as twenty percent[2]. When mercerization is carried out on tension fiber, the shape of coiled cotton fiber is changed: it straight out and the characteristics, lumen completely disappears[1, 9].

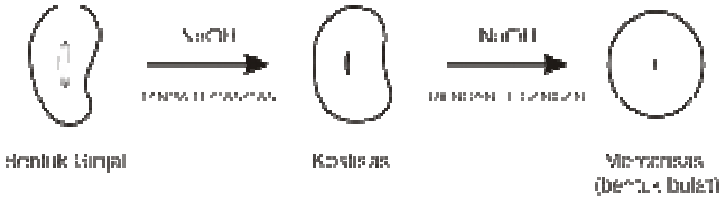

Figure 1: Morphological Change during Mercerization 9

Jordanov studied on, the strongly alkaline solution causes the fiber to swell up and become gelatinous and transparent in its structure. It gives greater absorptive properties and enhances dye uptake. It facilitates uniform dyeing in addition to improving the physical properties and a high degree of luster, depending on the method used[7,4]. The first true Indian designer was Mahatma Gandhi jee, who urged the people of India to wear khadi garments. Khadi is an Indian handspun and hand-woven cloth. Khadi is an eco-friendly textile. The raw materials may be cotton, silk, and wool which is spun into threads on a spinning wheel called a charkha. With the passage of time, this fabric has been changed in fashion fabric. *Khadi*, the Fabric of Freedom and Fashion, has been a source of livelihood for people. Spinning is mostly done by the girls as well as women in the villages, while weaving is dominated by men[8]. The cotton *khadi* is woven in such a way that the interlacing of threads provides a maximum exchange of air to the body, thus giving a cooling effect, making *khadi* ideal summer wear. Cotton Khadi fabric has various plus points over other fabric i.e. unique in texture, looks brilliant and produces in various weaves versatile fabric, cool in the summer and warm in the winter. It prevents skin rash and imparts a very elegant and sober look. It is comfortable fabric but it has some drawbacks such as it is hand woven and hand spun fabric so it has less luster and strength. Caustic soda concentration for mercerization treatment as reported in the literature[5, 11] varies from 11-19% (W/V). But there are no experimental and scientific details available in recommending this wide concentration range. The present study was planned to find out the effect of mercerization on dye-ability of gray cotton khadi fabric. The main objective of the present work was; to study the effect of various concentrations, time and temperature of mercerization treatment and the effect of percent dye exhaustion on control and mercerized samples.

EXPERIMENTAL

Material

This study was done on Grey cotton khadi fabric of fabric count i.e. 55 × 61, weighing 1.43 gm (GSM), and purchased from Khadi Bhandar, Jaipur, Rajasthan. Commercially available dyes (Reactive dye and Vat dye) were selected for the study to dyeing the treated and untreated fabric samples, purchased from the local market of Jaipur, Rajasthan. To remove the sized from the gray cotton khadi fabric, the desizing treatment was done and also to remove the waxes and oils attached to grey (natural) fabrics that interfere with proper dyeing, scouring treatment was given. Bleaching was done on all the samples at 90^{o}C for 30 min in a solution contains 4ml/l hydrogen peroxide (35%), 2g/l sodium carbonate and 2g/l stabilizer. All the experiments were carried out in the laboratory of Department of Clothing & Textiles, Banasthali University, Niwai (Tonk), Rajasthan.

METHODS

Mercerization Treatment

After De-sizing, scouring and bleaching, the mercerization treatment was given on grey cotton khadi fabric using two methods of mercerization i.e. slack mercerization and under tension mercerization. The treatment was done at three concentrations of Sodium Hydroxide palates i.e. 5%, 15%, and 25% for different time duration i.e. 10min, 20min and 30min at 40^{o} C. After this process the samples were washed with clean water and then dry to all the samples. The full treatments of Mercerization under tension had done in stretched (under tension) condition than dry the samples also in under tension condition.

Method of Mercerization under Tension

For the research work, wooden rollers **(2"×20")** were developed with the help of a carpenter. To continue the process of mercerization under tension, cut rectangle pieces of the cotton khadi fabric of 18" ×70" then end of the samples were astring with the rollers then make a solution of NaOH for the treatment in a tray at selected concentrations. The above ready sample was put into the solution in the relaxed condition for a control time period. After socking, the samples were taken out from the solution of caustic soda then stretched the samples till the mark of a marker, which was equal to the sample size the samples were rinsed using tap water in a stretched condition and dried in the same condition.

Dyeing

After mercerization treatment, each sample was equally divided into two parts for further dyeing meanwhile unmercerized and mercerized cotton khadi fabrics were dyed with reactive dye and vat dye using the standard method of pink color using 3% dye concentration. The whole process of dyeing was carried out in the laboratory. Dye-ability of all dyed fabric samples were assessed by subjective analysis. After mercerization treatment dyeing was done on all the mercerized and unmercerized (control) samples.

Determination of Percent Dye Exhaustion

To determine the percent dye exhaustion (an optical density) of the different dye solutions were measured before and after dyeing of mercerized and control samples of cotton khadi fabric by using single beam UV-Vis Spectrophotometer. Distilled water was taken as a blanked solution, 1 ml of dye solution was diluted with 10 - 20 times and optical density at 600nm wavelength was measured. In this, the sample remains the same but the wavelength was adjusted. Percent dye exhaustion was calculated as follows:

Percent dye exhaustion = O.D. (initial) – O.D. (final) $_{\times}$100/O.D. (initial)

Where:

O.D. (initial) - an optical density of the dye liquor before dyeing

O.D. (final) - an optical density of the dye liquor after dyeing

RESULTS AND DISCUSSIONS

Effect of Sodium hydroxide palates is well known, on the improvement of color yield. After the pretreatments, grey cotton khadi fabric was mercerized with sodium hydroxide pallets and determined its effect on the grey cotton khadi fabric using its different concentrations for different time durations at a single temperature. Then compared the dyeability

and percent dye exhaustion among control, slack and under tension mercerized cotton khadi fabric samples. These fabric samples gave very good results after mercerization treatment on cotton khadi fabric at different concentrations of NaOH i.e. 5%, 15% and 25% for the different time duration (10 min, 20min, and 30min), as given in Tables and Figures below.

Table 1: Absorbency Using Reactive Dye

Time	Concentration	Unstretched (Slack Mercerization)		Stretched (Under Tension Mercerization)	
		Before	After	Before	After
Control		8.3	7.04	16.3	14.04
10 min	5%	11.28	9.6	11.68	9.36
10 min	15%	8.6	7.52	13.32	12.12
10 min	25%	10.68	9.68	10.48	9.44
20 min	5%	13.08	12.86	11.12	10.08
20 min	15%	11.6	10.8	12.88	10.88
20 min	25%	14.44	10.6	11.88	9.80
30 min	5%	12.4	10.92	9.88	8.8
30 min	15%	10.18	9.6	11	8.1
30 min	25%	12	11.36	12.84	7.89

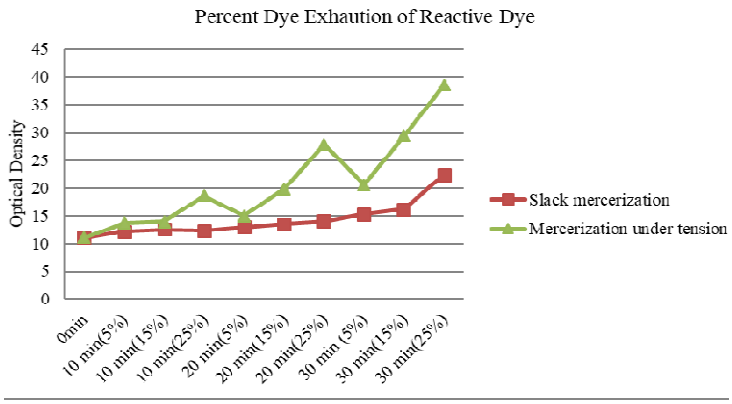

Figure 2: Percent Dye Exhaustion of Reactive Dye

Effect of the color absorbency, before dyeing and after dyeing on slack and under tension mercerized cotton khadi fabric samples is depicted in Table 1 and Figure 2 using reactive dye. In case of the control sample, before dyeing the absorption of reactive dye solution in the 600 nm color wavelength was 8.3 and after dyeing the absorption of dyes was decreased i.e. 7.04, it means; the control sample has property to absorb the dye and provide a very good color effect on the fabric surface. The reactive dye was absorbed by the control sample that is around 1%.In terms of slack mercerization treatment, as the time and concentrations were increased from 10 minutes to 30 minutes and 5% to 25% concentration, showed increasing absorbency respectively. In terms of Mercerization under tension the absorbency of dye solution before dyeing was 11.86 and after dyeing the absorbency of dye solution was decreased till 9.36 means the dyed cotton khadi fabric samples absorbed was more than 2% dye solution into the process of the fabric at 5% concentration of NaOH for 10 minutes time duration, as the time duration of the treatment and concentrations of NaOH was increased, the absorbency of the treated samples was also increased. As compared to the control samples the slack mercerized samples showed very good absorbency of reactive dye whereas under tension mercerized samples obtained excellent color absorbing properties. Though, it was increased in all dyed samples of mercerization under tension as compared to slack mercerized samples using reactive dye. Results are supported by the study of Goldthwait, C. *et al.* (1952) that the indication of swelling

behavior of cotton is expected to supplement the usual observation of mercerized yarn properties i.e. luster, strength and dyeing capacity[12]. A reactive dye can also be bonded with more than one fiber consequently increase the tensile strength[3, 13].

Table 2: Absorbency of Mercerized and Dyed Samples Using Vat Dye

Time	Concentration	Unstretched		Stretched	
		Before	After	Before	After
Control		7.98	7.32	7.98	7.32
10 min	5%	8.3	7.8	9.75	8.15
10 min	15%	9.15	9.13	9.95	6.66
10 min	25%	7.18	7.3	9.2	6.98
20 min	5%	7.8	8.2	8.8	6.44
20 min	15%	7.3	7.8	10.02	6.56
20 min	25%	7.33	6.9	10.1	6.1
30 min	5%	6.22	6.3	10.8	6.32
30 min	15%	7.1	6.9	12.8	7.28
30 min	25%	8.8	7.6	9.95	6.15

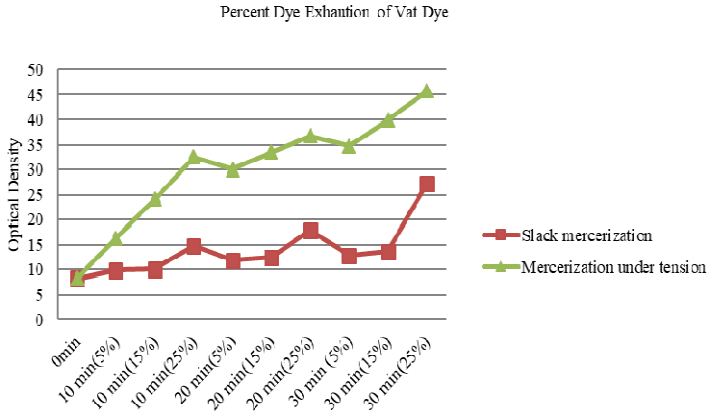

Figure 3: Percent Dye Exhaustion of Vat Dye

Table 2 and Figure 3 showed the absorbency of dyed cotton khadi fabric with vat dye. In terms of the control sample, before dyeing the color absorption of vat dye was 7.98% and after dyeing the absorption of dye solution was decreased i.e. 7.32, it means; the control sample has property to absorb the dye and provide good color shades of the fabric. In terms of slack mercerization treatment, before dying, the color solution absorbency was 8.3 at the wavelength of 600nm, after dyeing the color absorbency was 7.8, after dyeing the color absorbency was decreased, means the slack mercerized sample absorbed less than 1% color at 5% concentration of NaOH for 10 minutes time duration, at the same time duration and concentration of NaOH the absorbency of before dye color solution was 9.75 and after dyeing 8.15 and obtained more than 1% absorbency. It means, under tension mercerized cotton khadi sample showed good absorbency as compared to control and slack mercerized samples.

In case of 25% concentration of NaOH pallets for 30 minutes time duration, before dyeing the absorbency of vat dye solution obtained 8.8 and after dyeing it was 7.6 through the slack mercerized cotton khadi fabric samples obtained more than 1% absorption whereas in case of under tension mercerized samples before dyeing the dye solution showed 9.95 absorbencies while after dyeing it was decreased till 6.16. It means under tension mercerized cotton khadi fabric obtained the highest absorbency i.e. more than 3% with the increasing concentration of NaOH pallets and time duration. With the increasing time and concentrations, i.e. from 10 minutes to 30 minutes and 5% to 25% concentration, showed increasing

absorbency respectively. Though, it was increased in all dyed samples of mercerization under tension as compared to slack mercerized samples using vat dye. The results are supported by the study of Wagav*et al.*(2012) and Goldthwait, C. *et al.* (1952) that the chemical bond developed between dye and fibers which increase the dyeability and tensile strength of the fabric[11, 12].

Table 3: Percent Dye Exhaustion of Vat Dye and Reactive Dye

Time	Concentration of NaOH %	Vat Dye		Reactive Dye	
		SM	UTM	SM	UTM
Control		8.27	8.27	11.06	11.06
10 min	5	9.9	16.41	12.19	13.72
10 min	15	10.1	24.06	12.58	13.95
10 min	25	14.8	32.5	12.36	18.61
20 min	5	11.9	30.09	13.02	15.02
20 min	15	12.5	33.5	13.52	19.86
20 min	25	17.9	36.8	14.01	27.81
30 min	5	12.8	34.8	15.3	20.59
30 min	15	13.59	39.91	16.2	29.36
30 min	25	27.35	45.8	22.4	38.55

***SM=** Slack mercerization, UTM= under tension mercerization

Percent Dye Exhaustion of Reactive Dye and Vat Dye

It can be seen in the above Table 3 that the percent dye exhaustion of grey cotton khadi fabric was 8.27 and 11.06 with Vat and reactive dye respectively. The percent dye exhaustion of mercerized samples was 9.9, 10.1, and14.8 at 5%, 15% and 25% concentration of vat dye for 10min only whereas, at the same time duration and concentration of NaOH, the percent dye absorption of under tension mercerized cotton khadi sample was increased i.e. 16.41, 24.06, and 32.5. The percent dye absorption of under tension mercerized samples was also increased using reactive dye as compared to the slack mercerized and control samples. Means, As the time duration and concentration of NaOH palates, were increased the percent dye absorption was also increased. The percent dye absorption, of slack mercerized samples, was 15.3, 16.2, and 22.4 while of under tension mercerized samples was 20.59, 29.36 and 38.55 using reactive dye at 5% to 25 % concentrations of NaOH pallets for 10 -30 minutes. Though as the concentration of sodium hydroxide pallets was increased the absorbency of the Khadi fabric was also increase.

Slack mercerization gave very good result at 25% concentration of sodium hydroxide palates for 30 min time duration i.e. 22.5 optical density as compared to other slack mercerized and control fabric samples while under tension mercerized fabric samples obtained the best result at the same concentration of NaOH palates and same time duration was 45 optical density as compared to the other dyed samples. The percent dye exhaustion was increased in all cases of mercerization under tension and slack mercerization as compared to the control sample. Changes have occurred in the treatments, slack mercerization and mercerization under tension.

The results are supported by the study of Tiwari, and Jain (2017), Wagav*et al.* (2012) and Goldthwait, C. *et al.* (1952) that mercerizing process leads to the increase of dyeing absorption because of breaking the hydrogen bonds between the fibers in the crystalline regions and converting them to amorphous regions. This increase in vat dyeing is arranged during washing with alkali soap after the dyeing process. In addition, the increase of these spaces between fibers with the presence of vat dyeing may be the reason for the rise of the breaking load[11,3, 12]. After mercerization treatments the color fastness properties (rubbing, sunlight and wash fastness properties) and physical properties like Tensile strength &

drape-ability of khadi fabric samples were also improved and Shrinkage reduced. Hence it was concluded that as the time and concentration was increased and the percent dye exhaustion kept on increasing.

CONCLUSIONS

Commercially available cotton khadi fabric was treated with caustic soda solution at the 5%, 15%, 25% concentration of caustic soda and varying in time 10min, 20min, 30min were applied. It can be concluded from the results that as the time and concentration was increased, the percent dye exhaustion was also increased in the case of mercerization under tension as compared to the controlled and slack mercerized samples. Though, it can be concluded that vat dye gave very good percent dye exhaustion and dye affinity on Khadi as compared to the reactive dye using under tension mercerization treatment. Hence, the changes were noticed between both treatments i.e. mercerization under tension treatment obtained better results with the increasing in the time and concentrations and improved the other physical properties like Tensile strength & drape ability and reduce Shrinkage.

REFERENCES

1. *Akhbari M, Zahiri A & Bassam S J E, Fibres & Text in Eastern Europe, vol. 94 (5)2012, pp. 30–35.*
2. *Corbman B P, Textiles: Fiber to Fabric. (McGraw-Hill publication), 1983*
3. *Elrys M A, El-Hossini A & EL-Hadidy A M, J of Text, 2015*
4. *Jordanov I, Mangovska B &Tavcer P F ResearchGate. 59(10) 2010, 439-446*
5. *Karmakar S R, Chemical Technology in the Pre-Treatment Technology of Textile Processes, ELSEVIER, Amsterdam, Netherlands, 1999.*
6. *Tomar, S., & Sharan, M. A Glance at an Extinct Craft of Cotton Loin Cloth Production and Zari Border Weaving at MANDVI, surat.*
7. *Kim, S., Lee, E.S., & Yoon H S, Fiber and Polymer, (7)2006 186-190*
8. *Kumar P, 2015 Retrieved from https://www.linkedin.com/pulse/caustic-mercerization-liquid-ammonia-cotton-fabric.*
9. *Mishra N, Naturally Coloured Cotton Designer's Apparel: An Emerging Trend in Khadi World, Ph.d. Thesis, The University of Agricultural Sciences, Dharwad, 2012.*
10. *AB Kadir, M. I., Ahmad, M. R., & Ismail, A. The Effect of Cationic Surfactant Treatment on the Dyeability of Cotton and Silk Fabrics with Natural Dye from Brown Seaweeds Sargassum SP.*
11. *Shenai V A, Technology of Bleaching and Mercerization, Sevak Publications, Bombay, 1995, 493-500*
12. *Vatsala R, Textbook of Textiles and Clothing, Published by Indian Council of Agricultural Research, 2003, 158-169*
13. *Wagaw T & Chavan RB, Open Access Scientific Report, 1(9), 2012*
14. *Goldthwait C.F., Murphy A.L., Lohmann, I.W. Herbert O. $smith, H.O, Mercerization of Yarn—Experimental Apparatus and Techniques. Textile Research Journal August. 1952 vol. 22 (8):540-548*
15. *Onwuachu, U. I., Aboh, U. J. U. A., & IWUOHA, G. (2014). Extraction, characterization and workability of some local plants dyes as acid-base indicators. International Journal of Research in Applied, Natural and Social Sciences, 7, 1-6.*
16. *Tiwari, A & Jain R, Effect of Mercerization on the Drapability and Strength of Cotton Khadi Fabric. International Journal of Research in Applied and Natural and Social Sciences (IMPACT:IJRANSS). 4(4): 2017.*